Ref. No.: Ex/PG/ME/T/128A/2024

MME Second semester Examination, 2024

Subject: Principles and Applications of Linear Control Theory

Time: Three hours   Full Marks : 100

Answer any five questions

(All questions carry equal marks)

Question 1

Find out the transfer functions for the following three systems: -

a. An integrating operational amplifier
b. A resistive-inductive circuit
c. An armature controlled dc motor

Question 2

a. Comment of the stability of the following characteristic equation using Routh's criterion: -

$$s^4 + 2s^3 + 3s^2 + 4s + 6 = 0$$

b. For open loop transfer function

$$\frac{K(s-3)(s-5)}{(s+1)(s+2)}$$

Find out the break-in and break out points in root locus plot

c. For open loop transfer function

$$\frac{K(s+3)}{(s+1)(s+4)(s+5)(s^2+4s+5)}$$

Find out the angle of asymptotes and origin of asymptotes in root locus plot

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[Turn over

Question 3

Sketch Bode plot of the following system using asymptotes. The open loop transfer function of the system is given by

$$G(s)=\frac{20(s+1)}{s(s+2)(s+3)}$$

Question 4

a. Consider a system with unity feedback with $G(s)=\frac{8}{s+0.8}$. With the help of Bode plot (asymptotic) explain what happens to the phase margin when an integrator is added to the system.

b. Also discuss the effect of the integrator on position and velocity error constants

Question 5

a. Write down the transfer functions for lead and lag compensators.

b. Draw the Bode plots for lead and lag compensators.

c. Consider a unity feedback system with $G(s)=\frac{4}{s(s+2)}$. A lead compensator of the form $\frac{K_c\alpha(1+sT)}{(1+\alpha sT)}$ is added to the system. The requirements are as follows:-

$$K_v = \frac{20}{s}$$
$$PM = 50\ degrees\ approximate$$
$$GM = 10dB\ minimum$$

If the designer takes a value of $\alpha = 0.24$ and $\frac{1}{T} = 4.41$, please qualitatively explain the effectiveness of the lead compensator using Bode plot

Question 6

a. Find out the state transition matrix for the following system:-

$$\begin{Bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{Bmatrix} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix}$$

b. Check controllability and observability of the following system:-

$$\begin{Bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{Bmatrix} = \begin{bmatrix} 1 & 1 \\ -2 & -1 \end{bmatrix} \begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix} + \begin{Bmatrix} 0 \\ 1 \end{Bmatrix} u$$

Question 7

Consider the following single input single output system:-

$$G(s) = \frac{20(s+5)}{s(s+1)(s+4)}$$

Find out the state space representation

For a full state feedback control, find out the feedback gains for this system

Assume closed loop poles at $-5, -6 \pm 8j$